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RUNNING HEAD: Emotion in Frontotemporal Dementia

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Emotional evaluation and memory in behavioral variant frontotemporal dementia

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Abstract

Behavioral variant frontotemporal dementia (bvFTD) affects emotional evaluation, but less is known regarding patients' ability to remember emotional stimuli. Here, bvFTD patients and age-matched controls studied positive, negative and neutral pictures followed by a recognition memory test. Compared to controls, bvFTD patients showed a reduction in emotional evaluation of negative scenes, but not of positive or neutral scenes. Additionally, the patients showed an overall reduction in recognition memory accuracy, due to impaired recollection in the face of relatively preserved familiarity. These results show that bvFTD reduces emotional evaluation of negative scenes and impairs overall recognition memory accuracy and recollection.

Keywords: Frontotemporal Dementia, Emotion, Episodic Memory, Recollection

Frontotemporal dementia is a neurodegenerative syndrome characterized by alterations in behavior and cognition caused by progressive decline in the prefrontal and anterior temporal lobes (Lund & Manchester, 1994). Clinical presentation of the behavioral variant of FTD (bvFTD) primarily involves changes in behavior and personality such as apathy, depression, impulsivity, and disinhibition during social interactions (Rascovsky, et al., 2011). Consistent with these behavioral changes, neuropathological changes in bvFTD occur in frontal paralimbic regions (Chan, et al., 2001; Rosen, Gorno-Tempini, et al., 2002; Seeley, et al., 2008) that are involved in emotional perception and memory (for review see LaBar & Cabeza, 2006; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012). More recently, it has been suggested that bvFTD disrupts a large-scale brain network known as the salience network (Farb, et al., 2013; Zhou, et al., 2010), which includes anterior cingulate cortex, frontal pole, insula cortex, amygdala and striatum and responds to emotionally relevant stimuli (Seeley, et al., 2007). For these reasons, we sought to determine whether patients with bvFTD would show altered evaluation of and memory for emotional scenes.

Emotional Evaluation in bvFTD

Several studies have investigated emotional evaluation in bvFTD, but the majority has used only faces (e.g., Diehl-Schmid, et al., 2007; Fernandez-Duque & Black, 2005; Keane, Calder, Hodges, & Young, 2002; Lavenex & Pasquier, 2005; Lough, et al., 2006; Rosen, Perry, et al., 2002; Werner, et al., 2007). These studies have found that bvFTD affects the ability to interpret negative stimuli, but not positive stimuli. For example, Rosen, Perry, et al. (2002) showed patients with bvFTD and their age-matched controls photographs of neutral faces or of emotional ones depicting happiness, sadness, anger, or fear. They found

that patients were impaired on the perception of negative valence, but not of positive valence, when compared to controls. The impairment in negative emotional evaluation was correlated with atrophy in the right orbitofrontal cortex and amygdala. Importantly, bvFTD patients are unimpaired on the perception of non-emotional features of faces (Fernandez-Duque & Black, 2005; Keane, et al., 2002), suggesting that impairment is related to evaluation of emotion rather than face perception *per se*. One important consideration for interpreting changes in emotional evaluation in bvFTD is that positive faces may simply be easier to perceive than negative ones (e.g., Russell, 1994). Fernandez-Duque and Black (2005) found that bvFTD were equally impaired on an easy versus difficult emotional perception of negative faces, suggesting that task difficulty does not easily explain the valence differences in emotional evaluation in patients.

Although the data on faces are relatively clear, aside from a pair of studies with negative film clips (Werner, et al., 2007) and prosody (Keane, et al., 2002), much less is known about patients' interpretation of more complex emotional stimuli. In addition, little is known regarding whether bvFTD patients would have reduced ability to evaluate a wide range of positive stimuli. Positive stimuli can range in their extent of intensity and positivity (Lang, Bradley, & Cuthbert, 1998), and can include, in addition to happiness, other discrete positive emotions such as serenity, excitement and desire (Russell, 1980). All of the previous studies investigating the influence of FTD on emotional perception have included happiness as the sole positive emotional category, which raises the possibility that positive emotional evaluation in bvFTD may be impaired when a wider variety of positive stimuli is employed. Further, at present little is known regarding the consequence of altered emotional evaluation on memory.

Episodic Memory in bvFTD

Although not a clinical diagnostic criterion for FTD, memory impairment is frequently an accompanying feature in patients (for review see Hornberger & Piguet, 2012). Patients with bvFTD complain about memory loss (e.g., Hodges, et al., 2004), sometimes perform worse on standardized memory tests when compared to controls (Hornberger, Piguet, Graham, Nestor, & Hodges, 2010), and show reductions in the specificity of autobiographical memory retrieval (Irish, et al., 2011; Matuszewski, et al., 2006). However, the exact nature of memory related change in bvFTD has been unclear.

A couple of studies have examined recollection processes during memory recognition and shown that bvFTD patients are impaired. For example, Bastin et al. (2012) found that bvFTD patients were impaired on recollection during recognition memory for words as indicated by a reduction in the proportion of “Remember” responses when compared to healthy controls (also see Soderlund, Black, Miller, Freedman, & Levine, 2008). Further, deficits in recollection in bvFTD have been shown during retrieval of remote and personally relevant autobiographical memories (Piolino, et al., 2003).

Emotional Memory

In healthy controls, memory for emotional stimuli is generally more accurate when compared against neutral stimuli (for reviews see Buchanan, 2007; Kensinger, 2007) and is more likely to be associated with a greater sense of recollection (e.g., Kensinger & Corkin, 2003; Ochsner, 2000), which refers to the ability to recall contextual information or an associated sense of re-experience during memory retrieval as opposed to a mere sense of familiarity. Moreover, the emotional enhancement of memory occurs more frequently for negative experiences than positive ones. For example, Ochsner (2000) asked participants

to study negative, positive and neutral pictures, and then to complete a delayed recognition memory test using the Remember/Know procedure to assess recollection and familiarity. Ochsner found that recognition memory for negatively valenced and highly arousing pictures was associated with a greater sense of recollection, as indicated by a larger proportion of remember responses, whereas positively valenced pictures tended to be associated with a greater sense of familiarity.

The emotional enhancement of memory is linked to the modulatory effects of arousal mediated processes in the amygdala on encoding and consolidation processes in the hippocampus (for review see LaBar & Cabeza, 2006), as well as interaction between these regions and frontally mediated controlled processes that increase attention, elaboration, and organizational strategies during encoding of emotional valence (e.g., Kensinger & Corkin, 2004). Both the amygdala and prefrontal cortex are affected by bvFTD leading to poor performance on tests of emotional comprehension, but less is known regarding emotional memory. Irish and colleagues (2011) reported that during autobiographical memory retrieval patients with bvFTD recalled fewer emotions and thoughts in their autobiographical narratives when compared to controls and semantic dementia. More recently, Kumfor, Irish, Hodges and Piguet (in press) reported that bvFTD did not show an emotional enhancement in recognition memory accuracy for negative versus neutral pictures, which they linked to atrophy in the right amygdala and orbitofrontal cortex. To our knowledge, however, no study has examined memory specifically for both positive and negative stimuli in bvFTD, nor how emotion potentially contributes to qualitative changes in memory.

Current Study

The goal of the current study was to investigate the influence of bvFTD on evaluation and memory for emotional stimuli. We employed emotional pictures taken from the International Affective Picture Scale (IAPS; Bradley, Greenwald, Petry, & Lang, 1992) and other sources in order to study a wider variety of positive stimuli than has been previously used to investigate emotion in FTD. We focused on bvFTD because clinical and neuropathological changes in this subtype of FTD are known to influence emotional evaluation, and also because episodic memory may be impaired. bvFTD patients and age-matched controls were shown positive, negative and neutral pictures while rating emotional valence and intensity. Following a 30-minute delay, participants were given a recognition memory test that included an old/new decision followed by a Remember/Know response. Based on previous studies showing impaired emotional evaluation of negative versus positive stimuli (Rosen, Perry, et al., 2002), we predicted a reduction in the interpretation of negative pictures but not positive pictures in bvFTD versus controls. Given that bvFTD has a disproportionate effect on negative emotional evaluation, we additionally predicted that memory for negative pictures would be reduced in patients when compared to controls.

Material and Methods

Participants

Eleven patients with a clinical diagnosis of bvFTD (6 women), and fourteen age and gender matched controls (8 women) participated in the study (see Table 1). All bvFTD patients met the International bvFTD Criteria Consortium for diagnosis of bvFTD (Rascovsky et al., 2011): 1 patient met the criteria for possible bvFTD, and the remaining

10 patients were classified with probable bvFTD. SPECT images acquired on 10 of the bvFTD patients indicated that 5 were frontal variant (3 bilateral, 2 left-lateralized, 1 right-lateralized) and 5 were temporal variant (1 left-lateralized, 4 right-lateralized). Only bvFTD patients who were in the milder to moderate stages of dementia, as determined by Mini-Mental State Examination Scores (MMSE) of > 15 , were included. bvFTD patients were assessed for behavioral symptoms using the Neuropsychiatric Inventory (NPI), which was completed by their caregivers. Both groups of participants also completed the Positive and Negative Affective States (PANAS; Watson, Clark, & Tellegen, 1988) scale to assess current affective state. Exclusion criteria included current alcohol abuse or unreliable alcohol usage self-reports, a mood disorder, psychosis, or substance abuse within the past six months, or obsessive compulsive disorder, panic disorder, severe systemic disease or neurological disorder other than bvFTD.

Insert Table 1 Here

There were no group differences in age or education. As expected, the MMSE was lower in bvFTD patients than in controls, $t(22) = 3.17, p < .005$. PANAS scores revealed no group differences in the amount of current positive affect. However, there was a significant group difference in negative affect, $t(21) = -2.11, p < .05$, with the bvFTD patients reporting a greater amount of current negative affect compared to controls.

Design and Materials

Stimuli were selected from the International Affective Picture Scale (IAPS; Bradley, et al., 1992) and from the website (<http://pro.corbis.com/default.aspx>) Corbis Stock Photography to include positive, negative, and neutral pictures containing people. Valence (1 = negative, 3 = neutral, 5 = positive) and intensity (1 = low, 3 = medium, 5 = high) ratings

for each picture were obtained by an independent sample of 16 young, 11 middle age, and 14 older adult participants (age range: 19 – 83 years) using the Self-Assessment Manikin (SAM) rating system (Bradley, et al., 1992). Based on the ratings, 40 positive (Valence: *Mean* = 4.11, *SD* = 0.12; Intensity: *Mean* = 2.86, *SD* = 0.19), 40 negative (Valence: *Mean* = 1.36, *SD* = 0.17; Intensity: *Mean* = 3.75, *SD* = 0.31) and 40 neutral (Valence: *Mean* = 3.07, *SD* = 0.15; Intensity: *Mean* = 1.83, *SD* = 0.17) pictures were selected. The sets of pictures differed from one another in terms of valence and intensity ratings (all p 's < .0001). Although negative and positive pictures were more emotionally intense and valenced than neutral pictures, emotional intensity and valence were greater for the negative versus positive pictures. Two stimulus sets of 60 pictures (20 per valence category) were created and counterbalanced across participants to be used as studied or non-studied items. The sets were matched for content, the number of faces, gender and age, and mirrored each other in terms of the pilot ratings of valence and intensity.

Procedure

Study and test phases took place within the same study session and were separated by a 30-minute delay. In patients, the procedure was generally done on the same day as a clinic visit, and was never conducted during a first appointment for diagnosis at the clinic. During study participants viewed 60 randomly presented pictures while making concurrent valence (1 = Negative, 2 = Neutral, 3 = Positive) and intensity ratings (1 = low to 4 = high) on modified SAM scales; note that we simplified the valence and intensity ratings from the pilot study, for the sake of the patients. The pictures were displayed one at a time and remained on the screen until both rating responses had been made. Participants responded verbally and the experimenter entered their responses. Before beginning the

task participants conducted a practice trial for each valence category and were provided with feedback. If a participant responded incorrectly the experimenter reiterated the instructions. To ensure that participants understood the task they were reminded throughout about the rating instructions. Following study, a 30-minute delay was included in which participants were asked to complete some filler tasks (i.e., MMSE, PANAS, Demographic Information Form) until 30 minutes had elapsed.

During the test phase all 60 pictures from the study phase were presented in a random order along with 60 new pictures taken from the alternative set. For each picture participants were asked to make an old/new decision and old responses were followed by a Remember/Know decision. Participants were instructed that sometimes recognizing a picture brings back to mind thoughts, feelings or contextual information associated with the initial experience, whereas other pictures do not include such information, yet they are familiar. After responding “old,” participants were asked whether the picture brought back to mind information (i.e., Remember response) or whether it was just familiar (i.e., Know response). The pictures remained on the screen until the end of the response period. Participants responded verbally and the experimenter entered their response. For every 5 pictures in which a Remember response was made, the participants were asked to justify their response to the picture in order to ensure that they understood the Remember/Know instructions. Participants were also frequently reminded of the instructions throughout the duration of the test session. Two patients were excluded from the memory analyses because they did not understand the recognition instructions (i.e. responding “old” or “new” for all stimuli).

Results

Emotional Evaluation

To examine potential group differences in emotional evaluation we conducted separate Emotion (positive, negative, neutral) x Group (control, bvFTD) mixed design ANOVAs on the valence and intensity ratings acquired during study (see Table 2 for means and SD). Emotion was treated as a repeated measure and group as a between-subjects condition. The Huynh-Feldt correction was used to adjust for violations in the repeated measure assumption of sphericity and violations in the assumption of equality of variance were corrected as needed. To control for multiple comparisons, in the follow-up analyses we used bootstrapping with 1000 samples to adjust the reported p-values.

Insert Table 2 Here

Emotional Valence. First, we examined the emotional valence ratings. There was a significant Emotion x Group interaction on valence ratings, $F(1.70, 35.39) = 7.65$, $MSE = .07$, $p = .003$, $\eta_p^2 = .25$. Follow-up analysis revealed that there was a significant group difference for valence ratings of negative pictures, $t(10.43) = -2.47$, $p = .06$, but not for positive or neutral pictures, such that bvFTD patients rated the negative pictures as less negative when compared to controls. There was a significant main effect of emotion, $F(1.70, 35.39) = 291.93$, $MSE = .07$, $p < .0001$, $\eta_p^2 = .93$. Valence ratings were greater for positive ($M = 2.88$, $SD = .21$) versus neutral ($M = 2.05$, $SD = .22$), $t(24) = 13.52$, $p = .001$, negative ($M = 1.21$, $SD = .36$) versus neutral pictures, $t(24) = 13.24$, $p = .001$, and positive versus negative pictures, $t(24) = 17.07$, $p = .001$. The main effect of group was not significant, suggesting that there was no overall group bias in valence ratings across the pictures conditions.

Emotional Intensity. Next, we examined potential group differences in emotional intensity ratings. There was a trend for an Emotion x Group interaction on intensity ratings after correction for sphericity, $F(1.71, 39.38) = 2.82$, $MSE = .39$, $p = .08$, $\eta_p^2 = .11$. There was a main effect of emotion, $F(1.71, 39.38) = 30.63$, $MSE = .39$, $p < .0001$, $\eta_p^2 = .57$. Follow-up analysis revealed that negative pictures ($M = 3.36$, $SD = .63$) were rated as more intense than neutral pictures ($M = 2.10$, $SD = .72$), $t(24) = 6.12$, $p = .001$, positive pictures ($M = 3.11$, $SD = .56$) were rated as more intense than neutral pictures, $t(24) = 8.35$, $p = .001$, but there was no difference in intensity for negative versus positive pictures. There was also no main effect of group, which suggests that there were no group biases for intensity ratings across the picture conditions.

In sum, the results from the emotional evaluation analysis suggest that bvFTD might subtly and selectively affect the interpretation of negative pictures as indicated by a reduction in valence and a non-significant trend for intensity when compared to controls. In contrast, there were no group differences on emotion ratings for positive or neutral pictures.

Emotional Memory

To examine the impact of emotion on memory we examined overall recognition memory accuracy (Hits – False Alarms), Knowing (Know Hits – Know False Alarms), and Remembering (Remember Hits – Remember False Alarms), in separate Emotion (positive, negative, & neutral) x Group (bvFTD, Controls) ANOVAs (see Table 3 for means and SD). Emotion was treated as a repeated measure and group as a between-subjects condition. To control for multiple comparisons in the follow-up analyses we used bootstrapping with 1000 samples to adjust the reported p-values.

Insert Table 3 Here

Recognition Memory Accuracy (Hits – False Alarms). There was a significant main effect of emotion on recognition memory accuracy, $F(2, 42) = 4.42$, $MSE = .03$, $p = .02$, $\eta_p^2 = .17$. Recognition memory accuracy was greater for neutral ($M = .59$, $SD = .31$) versus positive pictures ($M = .44$, $SD = .26$), $t(22) = -2.82$, $p = .01$, and neutral versus negative pictures ($M = .48$, $SD = .26$), $t(22) = -2.67$, $p = .02$, but there were no differences in positive versus negative pictures, $t(22) = -.82$, $p = .41$. The main effect of group showed a trend, $F(1, 21) = 3.34$, $MSE = .16$, $p = .08$, $\eta_p^2 = .14$, which revealed that memory accuracy was reduced overall when collapsed across emotional category in FTD patients ($M = .39$, $SD = .23$) compared to controls ($M = .57$, $SD = .22$).¹

Remember and Know Responses. There were no significant interactions or group differences on the proportion of Know responses (hits – false alarms), nor in any follow-up analyses. It is important to note that these findings were the same irrespective of whether Know responses were adjusted to account for the assumption of independence between recollection and familiarity (Yonelinas & Jacoby, 1995).

For Remember responses, defined as Remember hits – Remember false alarms, there was a significant main effect of group, $F(1, 21) = 6.33$, $MSE = .11$, $p = .02$, $\eta_p^2 = .23$. The bvFTD group ($M = .24$, $SD = .19$) had a smaller proportion of Remember responses when compared to controls ($M = .45$, $SD = .18$). There was no main effect of emotion, or group x emotion interaction, on the proportion of Remember responses.

¹ We also note that separate analysis of hits and false alarms revealed that potential group differences in recognition memory accuracy were likely due a reduction in the hit rate rather than an increase in the false alarm rate (also see Table 1).

In sum, the results from the emotional memory analysis suggest that bvFTD affects recognition memory accuracy, particularly in the ability to recollect (i.e., Remember) the previously seen stimuli. Despite group differences in the evaluation of emotional pictures, however, the bvFTD were not differentially impaired on memory based on the particular emotional valence of the stimuli.

Discussion

The current study examined the evaluation of and memory for negative, positive and neutral emotional pictures in bvFTD. Compared to age-matched controls, bvFTD patients showed reductions in the ability to evaluate negative pictures, but they were not different from normal for positive or neutral pictures. Additionally, patients were impaired on recollection processes during memory recognition. It is important to point out that a reduction in evaluation for negative versus positive stimuli would be consistent with the positivity bias sometimes observed in healthy aging (for review see Carstensen & Mikels, 2005); however, controls were matched on age suggesting that the specific valence pattern observed here is abnormal. Further, the mean age in both groups is relatively “young” compared to aging studies that have observed the positive bias. Thus, our results suggest that while the accuracy and quality of memory are more generally impaired in bvFTD, differences in emotional evaluation of negative stimuli did not contribute to overall differences in memory for particular valence categories.

Emotional Evaluation

Prior studies examining emotional evaluation in bvFTD have consistently observed a reduction in the evaluation of negative stimuli, but preserved evaluation of positive stimuli (e.g., Fernandez-Duque & Black, 2005). However, previous studies have tended to

use positive stimuli from a single discrete emotional category (“happiness”), which are simpler and easier to identify (Russell, 1994). Consistent with previous studies, we show that bvFTD alters the interpretation of negative stimuli. Further, our study provides novel evidence by showing that emotional evaluation of positive stimuli in bvFTD is preserved even when a wider variety of discrete positive categories (e.g., happiness, excitement, erotic desire, etc.) are used. Fernandez-Duque & Black (2005) observed that bvFTD patients are impaired on identifying negative emotions irrespective of the level-of-difficulty across discrete negative emotional categories, suggesting that difficulty cannot easily explain valence differences. Our results support this idea by showing that bvFTD selectively impairs the evaluation of negative stimuli, even when more difficult positive emotional categories are queried.

Although several studies have investigated the ability to identify the valence or discrete category of emotional stimuli in bvFTD, less is known regarding how bvFTD affects the intensity or emotional response to such stimuli. Here we found some preliminary indication that, in addition to impairing the ability to identify negative valence, bvFTD may also slightly reduce the emotional intensity associated with viewing negative pictures. Werner and colleagues (2007) asked bvFTD, semantic dementia patients, and controls to watch fearful, happy and sad film clips. They found no differences between patients and controls in physiological response or facial expression, despite impairment in emotional evaluation of fearful and sad films. Thus, it is possible that there is a decoupling between physiological responses and reporting of subjective emotional response in FTD. A blunted emotional response is in line with symptoms of bvFTD, which include an increase in apathy (Rascovsky, et al., 2011). Incurring an angry or insulted response to a behavior might

therefore not discourage the behavior. Reduced emotional responses might also account for impairments on some types of theory of mind tasks (e.g., Gregory, et al., 2002).

Emotional intensity is frequently rated as higher for negative versus positive stimuli, as was the case in the current study. Thus, it is possible that the reduction in negative intensity in bvFTD is not specific to negative valence *per se*, but reflects a blunted emotional response to higher levels of intensity. An important question for future research is whether the reduction in emotional intensity in bvFTD versus healthy controls for negative stimuli is specific to valence or intensity level.

Episodic Memory: Remembering versus Knowing

Memory impairment is not a diagnostic feature of FTD, although it is frequently an accompanying one. Here we found that bvFTDs have a reduced hit rate, but normal false alarm rate, when compared to age-matched controls. Further, we show a trend for an overall reduction in memory accuracy on a delayed recognition memory task in patients. These findings are consistent with previous reports of anterograde memory loss in bvFTD (Hornberger & Piguet, 2012). We also observed that the reduction in recognition memory was specific to recollection processes, as indicated by a reduced proportion of remember responses during recognition memory, in bvFTD compared to controls. These results are in line with previous studies that have reported deficits in recollection in bvFTD (Bastin, et al., 2012; Piolino, et al., 2003; Soderlund, et al., 2008). Complementing these findings, Pasquier, Grymonprez, Lebert, and Van der Linden (2001) showed that bvFTD patients performed worse when memory was tested using an explicit versus an implicit task. Here we show, that such deficits in recollection by bvFTD also extend to memory for emotional scenes.

On the one hand, reductions in memory performance in bvFTD may be secondary to executive dysfunction, such as poor attention and an inability to employ strategic controlled processes during memory encoding and/or retrieval, linked to decline in the prefrontal cortex (for review see Neary, Snowden, & Mann, 2005). Consistent with this idea, some studies have shown that memory reductions in bvFTD are associated with impaired strategic controlled processes. For example, using a process dissociation procedure that separates automatic and controlled processes in memory, Collette, Van der Linden, and Salmon (2010) found that bvFTD were impaired on controlled but not automatic processes during a cued-recall task when compared to controls. Several studies have shown that autobiographical memory in bvFTD is impaired irrespective of the particular time period of the memory (i.e., lack of a temporal gradient; Irish, et al., 2011; Matuszewski, et al., 2006; Piolino, et al., 2007; Piolino, et al., 2003), suggesting a specific difficulty in memory retrieval rather than encoding. Simons et al. (2002; exp. 3) observed that bvFTD patients, compared to controls, were disproportionately impaired on source memory versus item recognition, and that source memory performance in bvFTD was correlated with performance on a composite score of frontal function. Similarly, Pennington, Hodges, and Hornberger (2011) found that frontal atrophy in bvFTD was correlated with memory performance on standardized tests.

On the other hand, reductions in memory in FTD may reflect more pure memory impairment linked to decline in the hippocampus. Retrieval support does not consistently improve memory in FTD, suggesting that memory impairment may reflect a true memory impairment rather than inefficient retrieval strategies that operate on the contents of memory. In one study, Glosser, Gallo, Clark, and Grossman (2002) found no benefit in

memory in bvFTD in cued versus free recall. Similarly, Irish and colleagues (2011) observed that retrieval support, in the form of extensive specific probes, did not augment detailed recall of autobiographical memory in bvFTD patients compared to controls. Atrophy in the hippocampus has been observed in bvFTD (van de Pol, et al., 2006), and the degree of hippocampal atrophy correlates with memory performance in patients (Kumfor, et al., in press; Lavenex, Pasquier, Lebert, Pruvot, & Petit, 1998; Soderlund, et al., 2008). Moreover, severe amnesia has been observed in pathologically proven FTD (Caine, Patterson, Hodges, Heard, & Halliday, 2001; Graham, et al., 2005).

Limitations

In the present study, we did not observe an emotional enhancement effect on memory accuracy (or recollection); rather, neutral pictures were actually better recognized than negative or positive pictures- a pattern that is sometimes observed (for review see Bennion, Ford, Murray, & Kensinger, 2013). The atypical pattern of emotional enhancement in memory does not affect interpretation of the overall reductions in accuracy and quality of memory in bvFTD, but may have contributed to the lack of the predicted reduction in memory for negative pictures in the patients when compared to controls. Future work should examine these effects using stimuli and other methods that may more reliably elicit an emotional enhancement in memory in order to better understand how changes in emotional evaluation in bvFTD potentially contribute to changes in emotional memory.

An additional limitation of the current study is the small sample size, which could have contributed to reduced power for detecting *a priori* interactions between group and emotion. One advantage of the current study is that we focused in particular on the behavioral variant of FTD, which allowed us to demonstrate clear differences in overall

recognition memory and in the contribution of recollection and familiarity to memory in bvFTD. Including a larger sample to investigate evaluation of and memory for emotional stimuli could allow for greater specificity regarding these effects on different variants of FTD.

Conclusions

The current study investigated evaluation of and memory for emotional stimuli in bvFTD. Commensurate with previous studies, we found that bvFTD impaired the ability to evaluate negative pictures, but preserved emotional evaluation of positive and neutral pictures. Consistent with a small number of previous reports, we found that recognition memory accuracy (and recollection) were impaired in the bvFTD patients. Understanding the potential influence of changes in emotional evaluation on memory in bvFTD presents an important avenue of future research that may help to better characterize potential memory impairment in patients.

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Table 1. Demographic Information

	bvFTD	Controls
Age	59.93 (11.82)	64.18 (6.69)
Education	13.90 (2.60)^	16.38 (3.73)^
Mini Mental State Exam	25.50 (4.97)^	29.71 (0.61)
PANAS		
positive	31.33 (6.76)	29.93 (8.75)"
negative	17.56 (6.77)"	12.79 (4.15)

missing data from ^ one subject, " two subjects

bvFTD = behavioral variant frontotemporal dementia

PANAS = positive and negative affective states

Table 2. Emotional Evaluation

	bvFTD <i>M (SD)</i>	Controls <i>M (SD)</i>
Valence		
Positive	2.79 (.29)	3.00 (.07)
Negative	1.41 (.47)	1.06 (.08)
Neutral	2.07 (.27)	2.03 (.18)
Intensity		
Positive	3.02 (.59)	3.19 (.55)
Negative	3.05 (.71)	3.60 (.46)
Neutral	2.24 (.86)	1.99 (.60)

bvFTD = behavioral variant frontotemporal dementia

Table 3. Emotional Memory

	bvFTD <i>M (SD)</i>	Controls <i>M (SD)</i>
Hits		
Positive	.72 (.28)	.87 (.15)
Negative	.67 (.28)	.85 (.13)
Neutral	.73 (.27)	.92 (.10)
False Alarms		
Positive	.34 (.31)	.38 (.26)
Negative	.33 (.21)	.28 (.24)
Neutral	.26 (.26)	.25 (.25)
Hits - False Alarms		
Positive	.38 (.28)	.48 (.24)
Negative	.33 (.23)	.58 (.25)
Neutral	.46 (.31)	.68 (.30)
Remember (Hits - False Alarms)		
Positive	.21 (.17)	.37 (.22)
Negative	.22 (.21)	.48 (.20)
Neutral	.31 (.28)	.48 (.26)
Know (Hits - False Alarms)		
Positive	.17 (.21)	.13 (.23)
Negative	.09 (.12)	.11 (.20)
Neutral	.16 (.23)	.23 (.29)

bvFTD = behavioral variant frontotemporal dementia